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BOTANICAL EVIDENCE OF A POST-PLEISTOCENE MARINE CONNECTION BETWEEN HUDSON BAY AND THE ST. LAWRENCE BASIN

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INTRODUCTION

FLORISTIC studies about the region of Hudson Bay have suggested an interesting phytogeographical problem. Among the many species of plants reported from this area are several of maritime occurrence. The nearest representatives of these plants are found along the Atlantic seaboard, about the region of the Gulf of Lawrence. Such cases of discontinuous distribution are fairly common, but the agencies responsible for these phenomena are not always the same.

It is the purpose of this paper to examine the various environmental agencies which might effect the distribution of these maritime plants and to determine, if possible, or at least to suggest, which factor has been most important. The writer wishes to express his sincere appreciation of the never-failing kindness and assistance of all members of the staff of the Gray Herbarium. Particular thanks are due, also, to Mr. C. M. Pomerat for his help in the field-work. Above all is the writer indebted to Professor M. L. Fernald, whose inspiration and guidance have made this work possible.

THE DISTRIBUTION OF CERTAIN HALOPHYTIC PLANTS
OF THE HUDSON BAY REGION

Of the numerous plants collected by the writer around the southern region of Hudson Bay, during the summer of 1929, the following species were found representing this peculiar distribution: *Zan-nichellia palustris* L. var. *major* (Boenn.) Koch; *Glaux maritima* L. var. *obtusifolia* Fernald; *Juncus Gerardi* Loisel.; *Carex maritima* O. F. Mueller; *Carex norvegica* Willd.; *Carex glareosa* Wahlenb. var. *am-phigena* Fernald; *Plantago juncoides* Lam. var. *decipiens* (Barneoud) Fernald; *Poa eminens* J. S. Presl and *Scirpus rufus* (Hudson) Schrad.

Associated with these plants were found the following indifferent halophytes, whose occurrence in this region may or may not have been brought about by the same agencies as effected the distribution of the above-mentioned halophytes: *Potamogeton filiformis* Pers.; *Triglochin maritima* L.; *Triglochin palustris* L.; *Scirpus americanus* Pers.; *Juncus balticus* Willd. var. *littoralis* Engelm.; *Potentilla An-serina* L.; *Myriophyllum exalbescens* Fernald; *Lathyrus maritimus* (L.) Bigel.; *Arenaria peploides* L. and *Mertensia maritima* (L.) S. F. Gray. To the above list should be added *Bidens hyperborea* Greene, an estuarian species, and *Zostera marina* L., a plant confined strictly to salt water. Maps 1-6 give the geographic ranges¹ of the strict

¹ The geographic ranges are based upon specimens in the Gray Herbarium and in the Herbarium of the New England Botanical Club, and upon the following publications:

Alcock, F. J., List of Plants Collected Along the Churchill River between Missi Falls and the Mouth of the Little Churchill River. Geol. Surv. Can., Summ. Rep. for 1915, p. 136.

Bell, John, On the Plants of Manitoulin Island. Geol. Surv. Can., Rep. of Prog., 1866-1869.

Bell, Robert, Report on Exploration of the Churchill and Nelson Rivers and around God's and Island Lakes. Geol. Surv. Can., Rep. for 1878-79, pp. 1-72 C.

Bell, Robert, List of Plants Collected in 1880. Geol. Surv. Can., Rep. for 1879-80, p. 59 C.

Bell, Robert, List of Plants Collected in Hudson Straits. Geol. Surv. Can., Ann. Rept. xi. 1898, pp. 34-37 M.

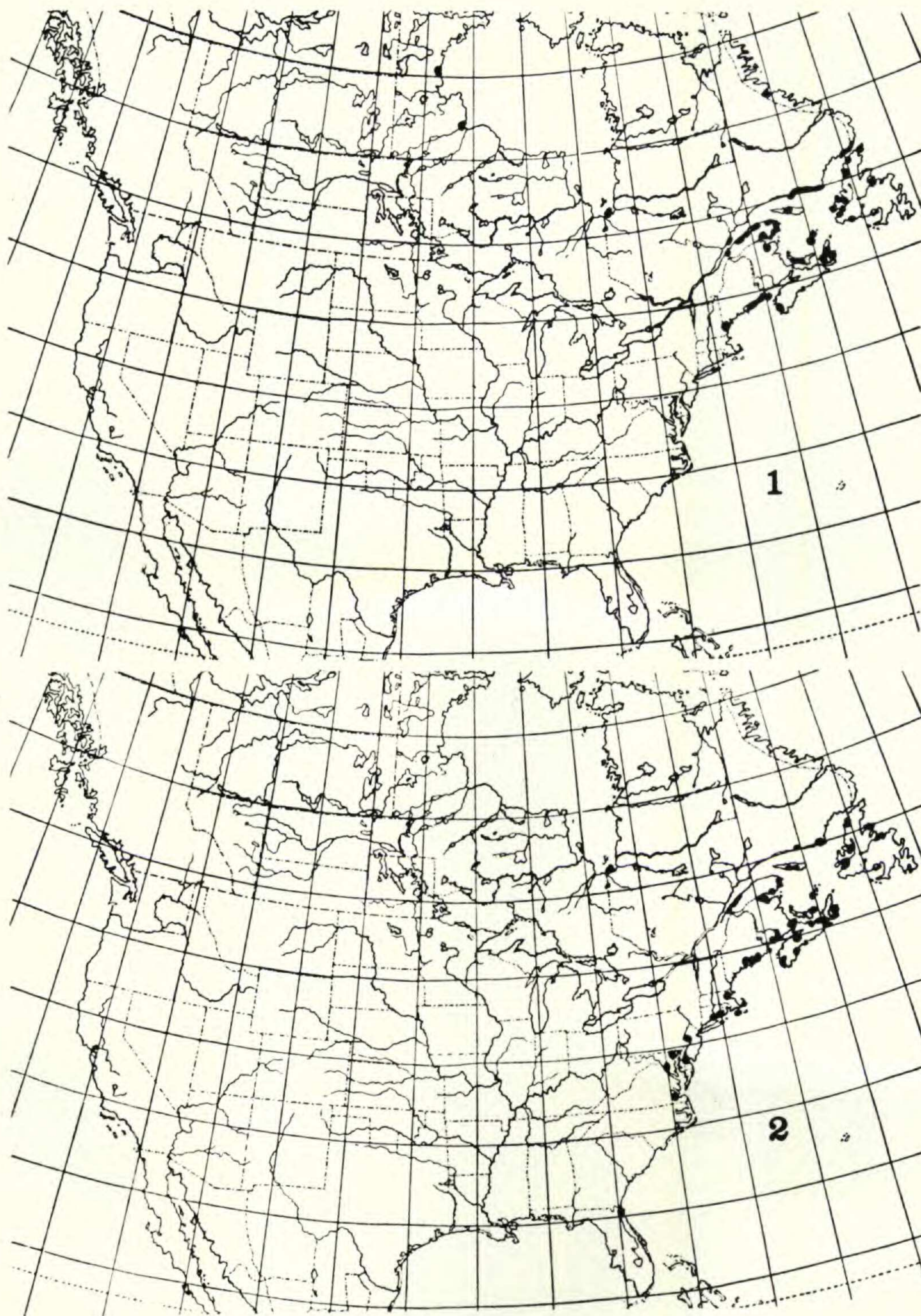
Dowling, D. B., List of Plants Collected at the Mouth of the Ekwan and Albany Rivers. Geol. Surv. Can., Ann. Rep. xiv. pt. F, p. 60.

Drummond, A. T., The Distribution of Plants in Canada in Some of its Relations to Physical and Past Geological Conditions. Can. Nat., n. s. iii. (1869) pp. 161-177.

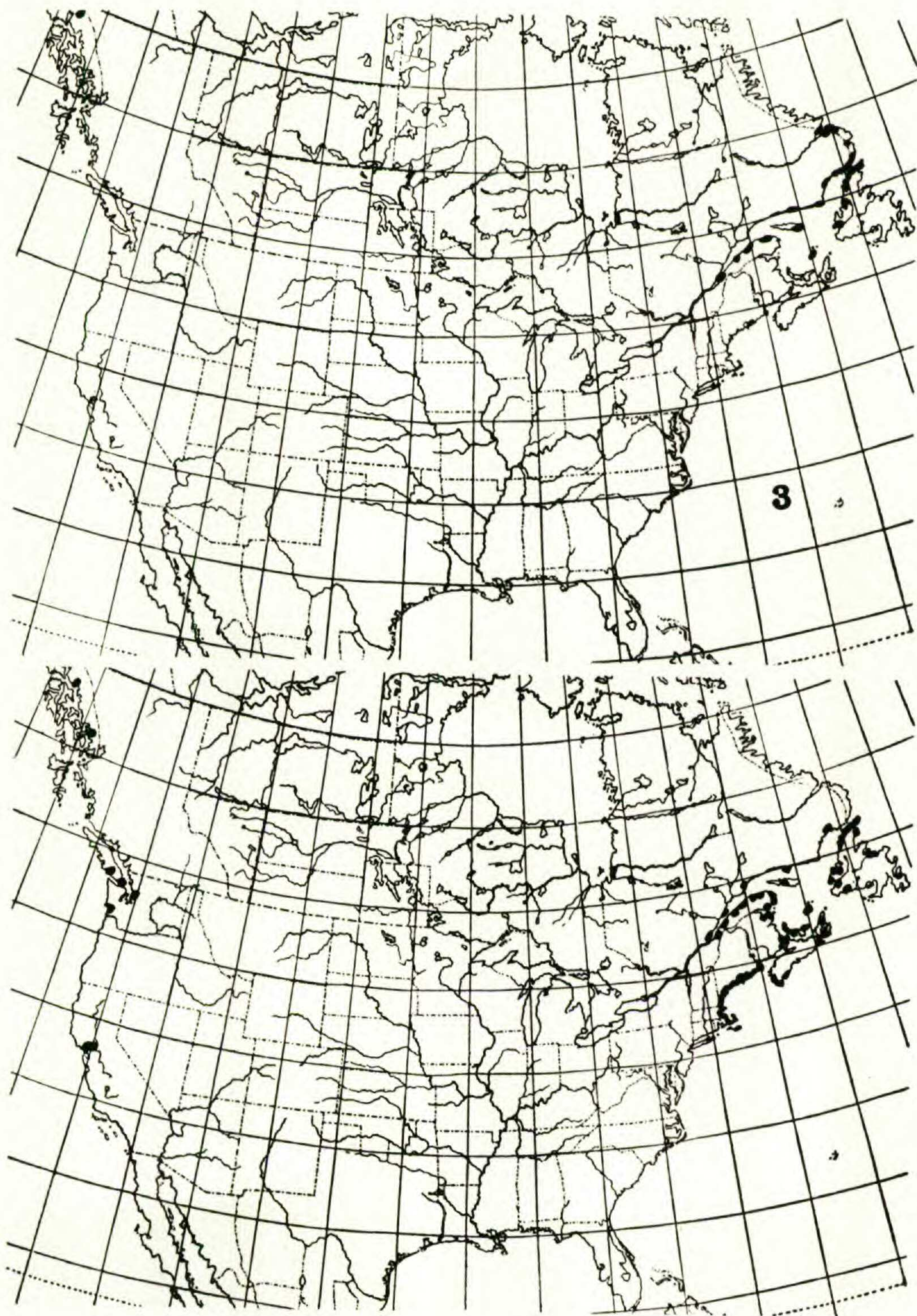
Drummond, A. T., The Distribution of Some Canadian Plants, an Argument for the Marine Origin of the Erie Clays. Can. Nat., n. s. vii. (1874) pp. 217-223.

Fernald, M. L., The Botanical Evidence of Marine Conditions in Hamilton Inlet, Labrador. In the Privy Council, In the Matter of the Boundry Between the Dominion of Canada and the Colony of Newfoundland in the Labrador Peninsula. Report of the Lords of the Judicial Committee of the Privy Council, delivered the 1st March, 1927, London.

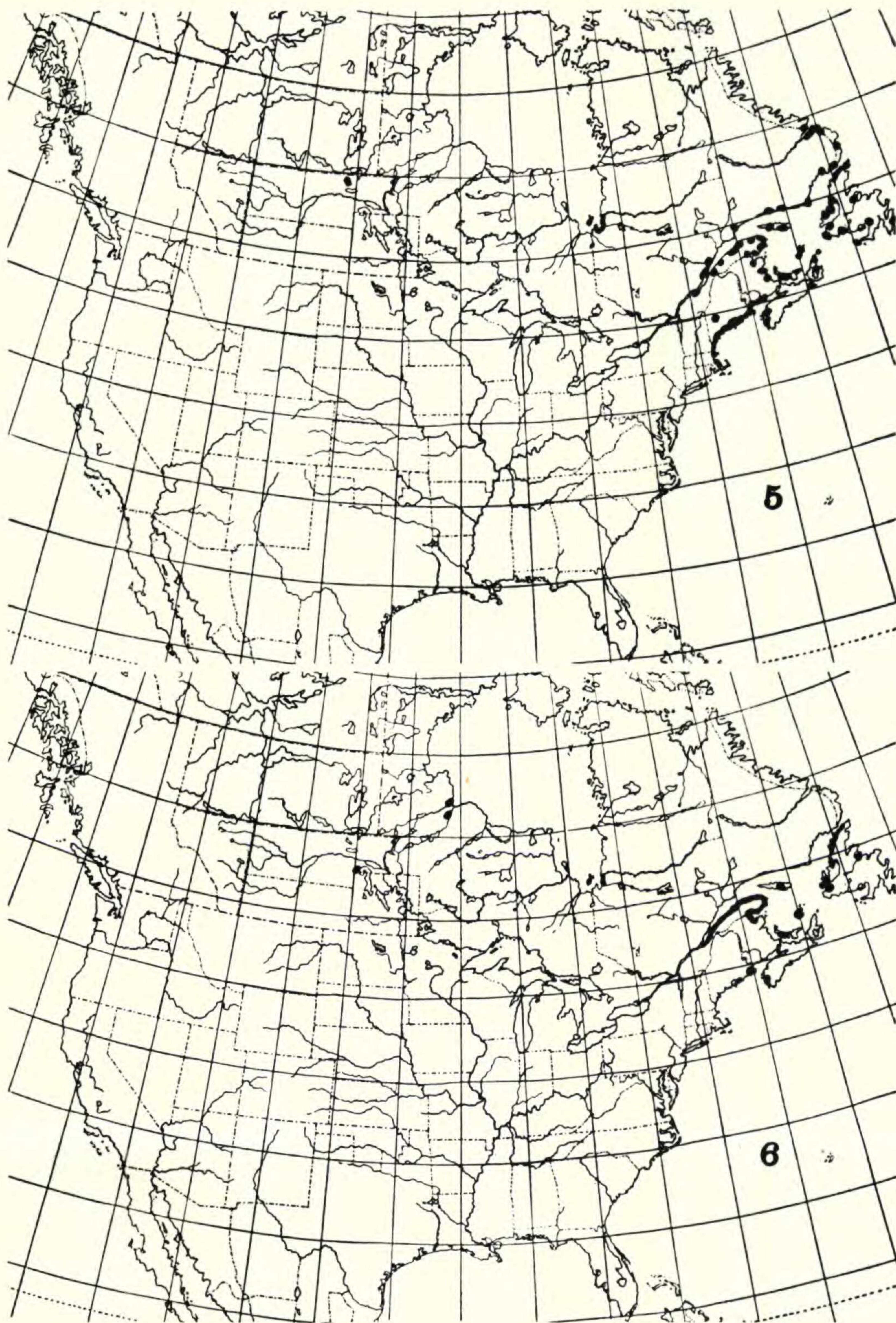
Henderson, A., Agricultural Resources of Abitibi. Rept. Bur. Mines, Ont., xiv. pt. 1, p. 241.



Map 1, Geographic Range of *Carex norvegica*;
2, of *Zannichellia palustris*, var. *major*.



Map 3, Geographic Range of *Poa eminens*;
4 (lower), of *Glaux maritima*, var. *obtusifolia*.



Map 5, Geographic Range of *Carex maritima*;
6, of *Scirpus rufus*.

halophytes listed above. In addition to their occurrence in the Hudson Bay region, it will be noted that in the cases of *Carex norvegica* (MAP 1) and *Zannichellia palustris* var. *major* (MAP 2) they are restricted to the Atlantic seaboard, extending at least from southern Labrador south along the New England coast, and in the case of *Zannichellia palustris* var. *major* south to Florida. *Poa eminens* (MAP 3) and *Glaux maritima* var. *obtusifolia* (MAP 4) have northeastern ranges somewhat similar to those mentioned above, but they appear also on the Pacific coast. The distribution of *Carex maritima* (MAP 5), *Scirpus rufus* (MAP 6) and *Juncus Gerardi* (MAP 7) varies from the strictly maritime, in that the two former species occur in the region just north and west of Lake Winnipeg, while the latter has been reported from the Finger Lakes district of New York and at the southern tip of Lake Michigan, as well as from the Pacific coast.

In the cases of *Plantago juncoides* var. *decipiens* (MAP 8) and *Carex glareosa* var. *amphigena* (MAP 9), both found farther north along the Labrador coast, they occur also on the southwestern coast of Greenland. *Zostera marina* (MAP 10) occurs from Labrador and the lower St. Lawrence south to North Carolina, in James Bay, along the north Pacific coast and on the southwestern coast of Greenland.

Bidens hyperborea (MAP 11), an estuarian species, has been studied by Fassett (29) and Fernald (31) and the data regarding its distribution are taken from their papers. It is interesting to note that this plant occurs exclusively on fresh tidal mud in estuaries from eastern Massachusetts to Quebec, then jumps to Rupert River, James Bay.

Macoun, J., Catalogue of Canadian Plants. Geol. and Nat. Hist. Surv. Can., 1883-1884, pts. 1-4.

Macoun, J., Comparison of Plant Distribution. Geol. Surv. Can., Rept. of Prog. 1875-1876.

Macoun, J. M., List of Plants in Low's Report of the Mistassini Expedition. Geol. and Nat. Hist. Surv. Can., Ann. Rept., 1885, pt. D.

Macoun, J. M., List of Plants in Low's Report on Exploration in James Bay and Country East of Hudson Bay. Geol. Surv. Can., Ann. Rept., iii. (1887) pt. J.

Macoun, J. M., List of Plants in Low's Report on Labrador. Geol. Surv. Can., Rept. of Prog. 1895, App. vi.

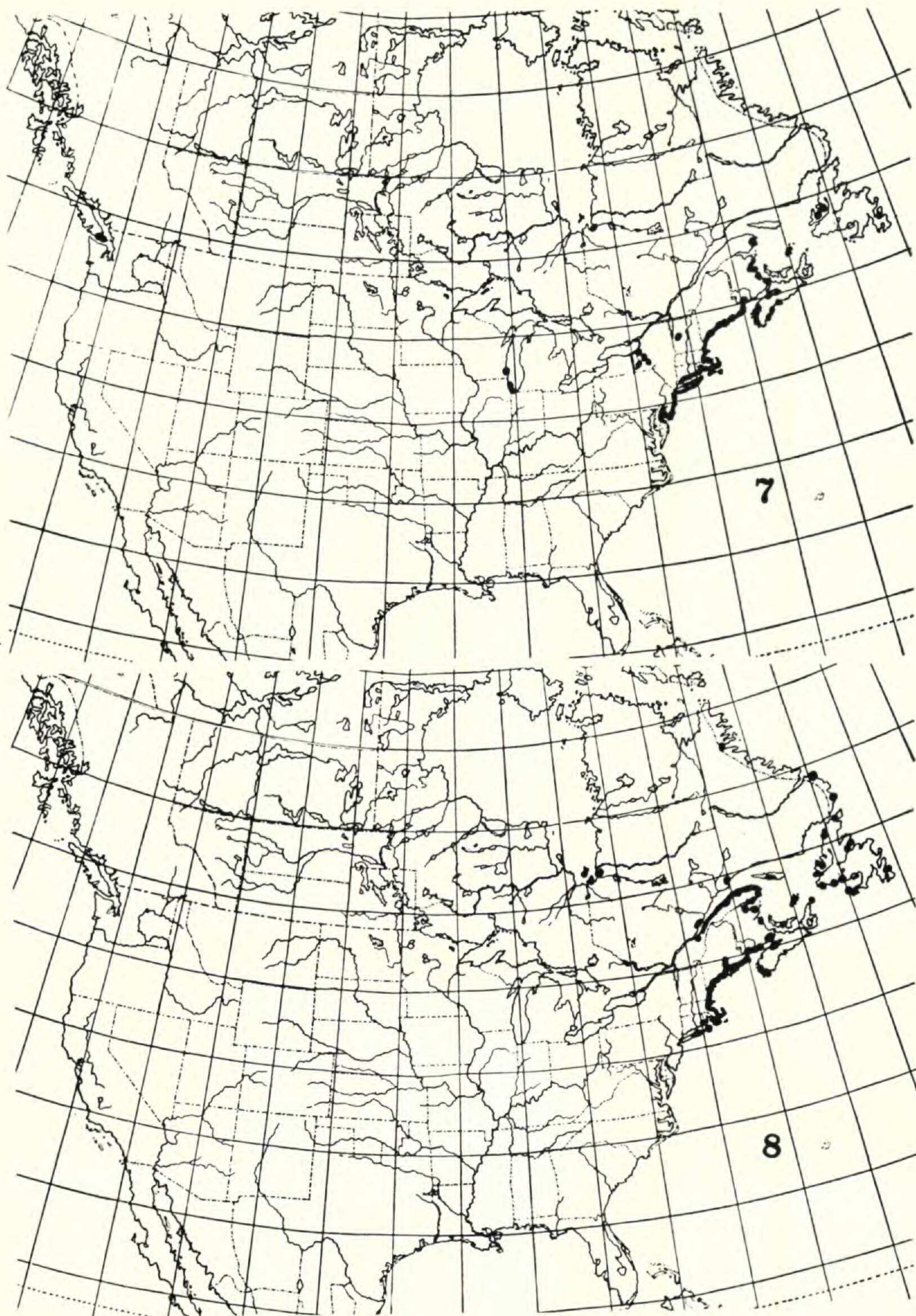
Richardson, Jas., Report on the Country North of Lake St. John. Geol. Surv. Can., Rept. of Prog., 1870-71, pp. 306-308.

St. John, H., A Botanical Exploration of the North Shore of the Gulf of St. Lawrence. Can. Dept. Mines, Mem. No. 126, 1922.

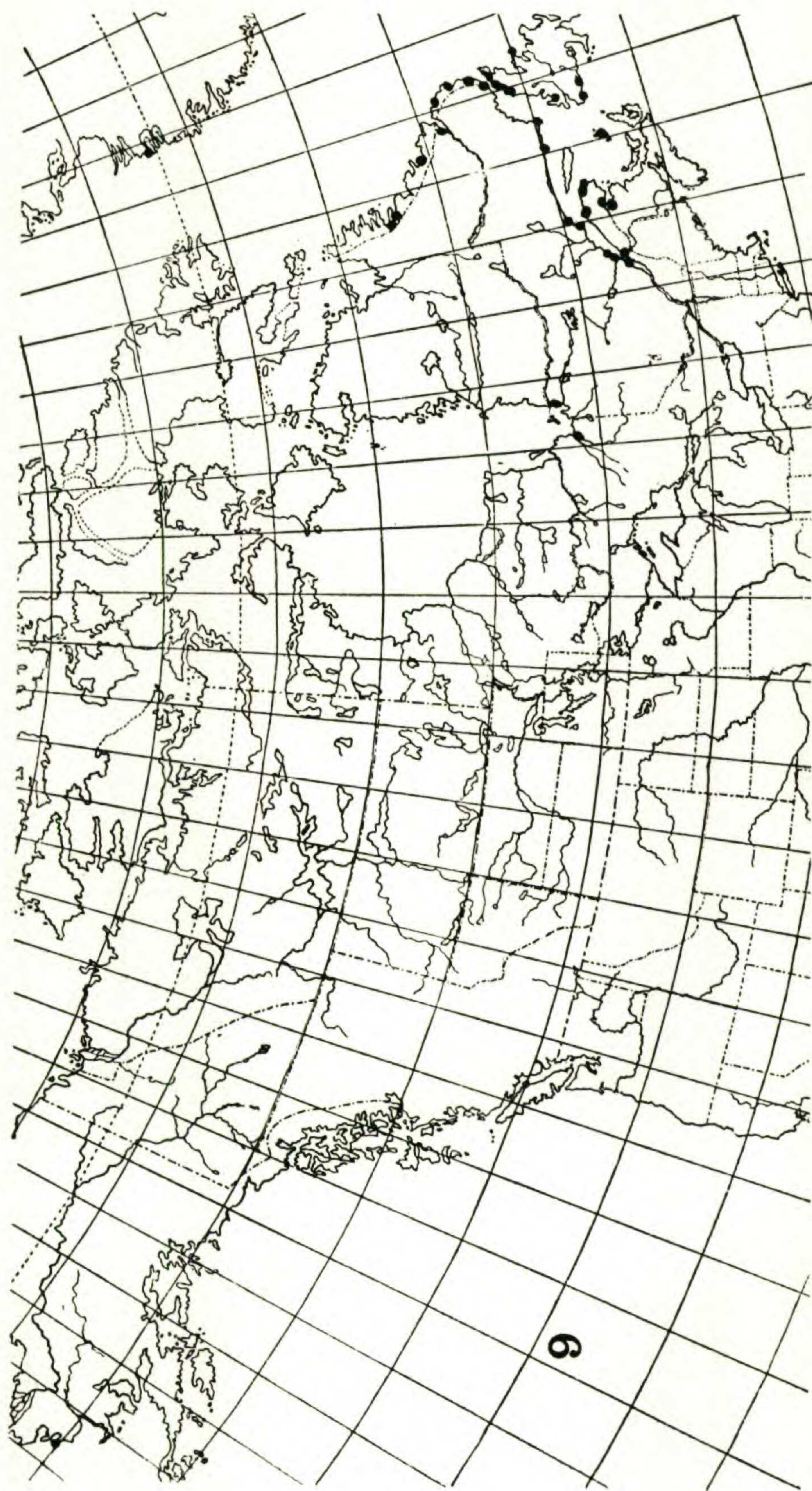
Svenson, H. K., Studies on Interior Distribution of Maritime Plants. I. RHODORA xxix. pp. 41-48; 57-72; 87-93; 105-116.

Tyrell, J. B., Plants Collected Between Lake Athabasca and the West Coast of Hudson Bay, north shore of Hudson Straits and Fort Churchill. Geol. Surv. Can., Ann. Rept. ix. (1896) p. 205 F.

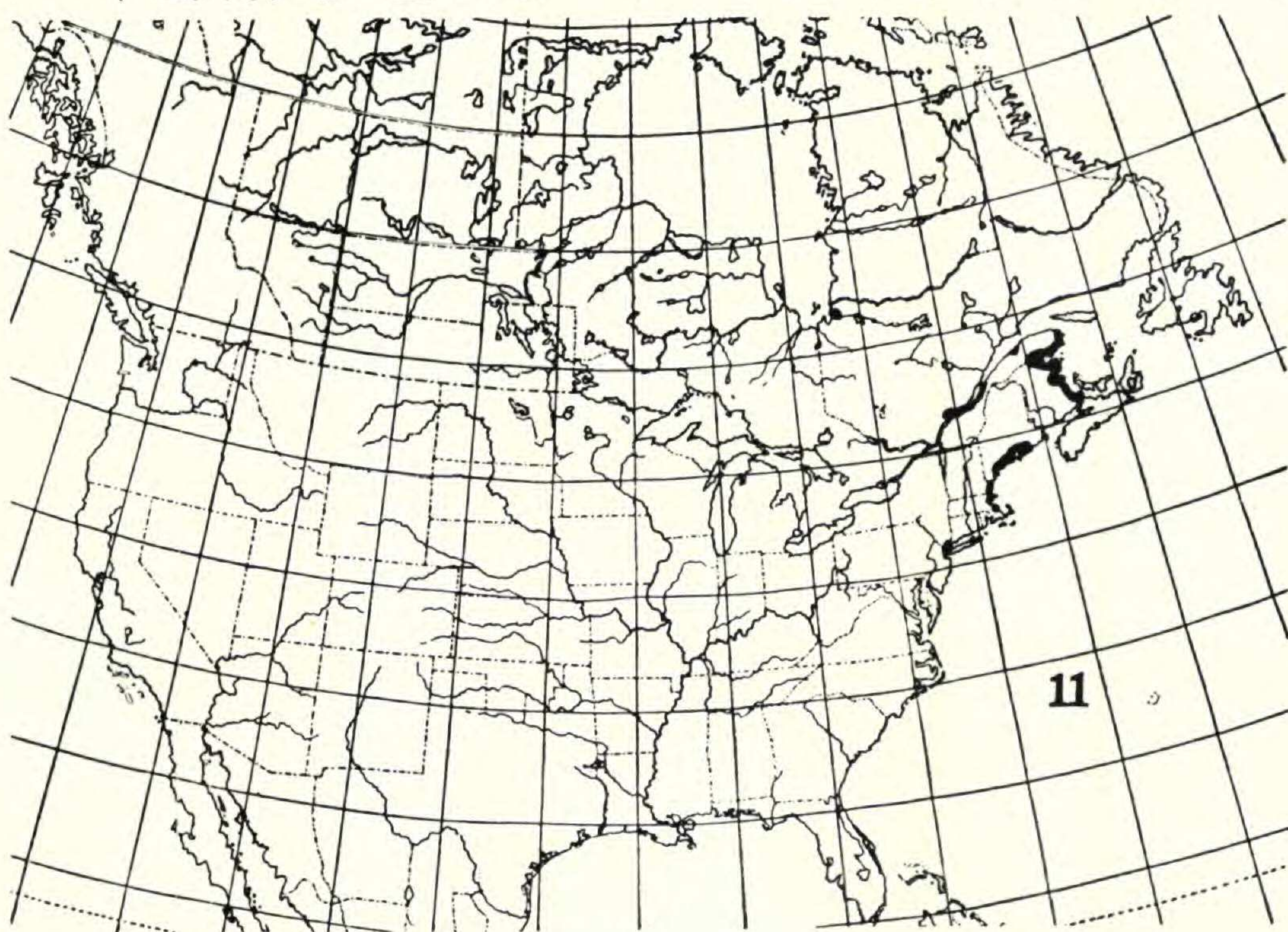
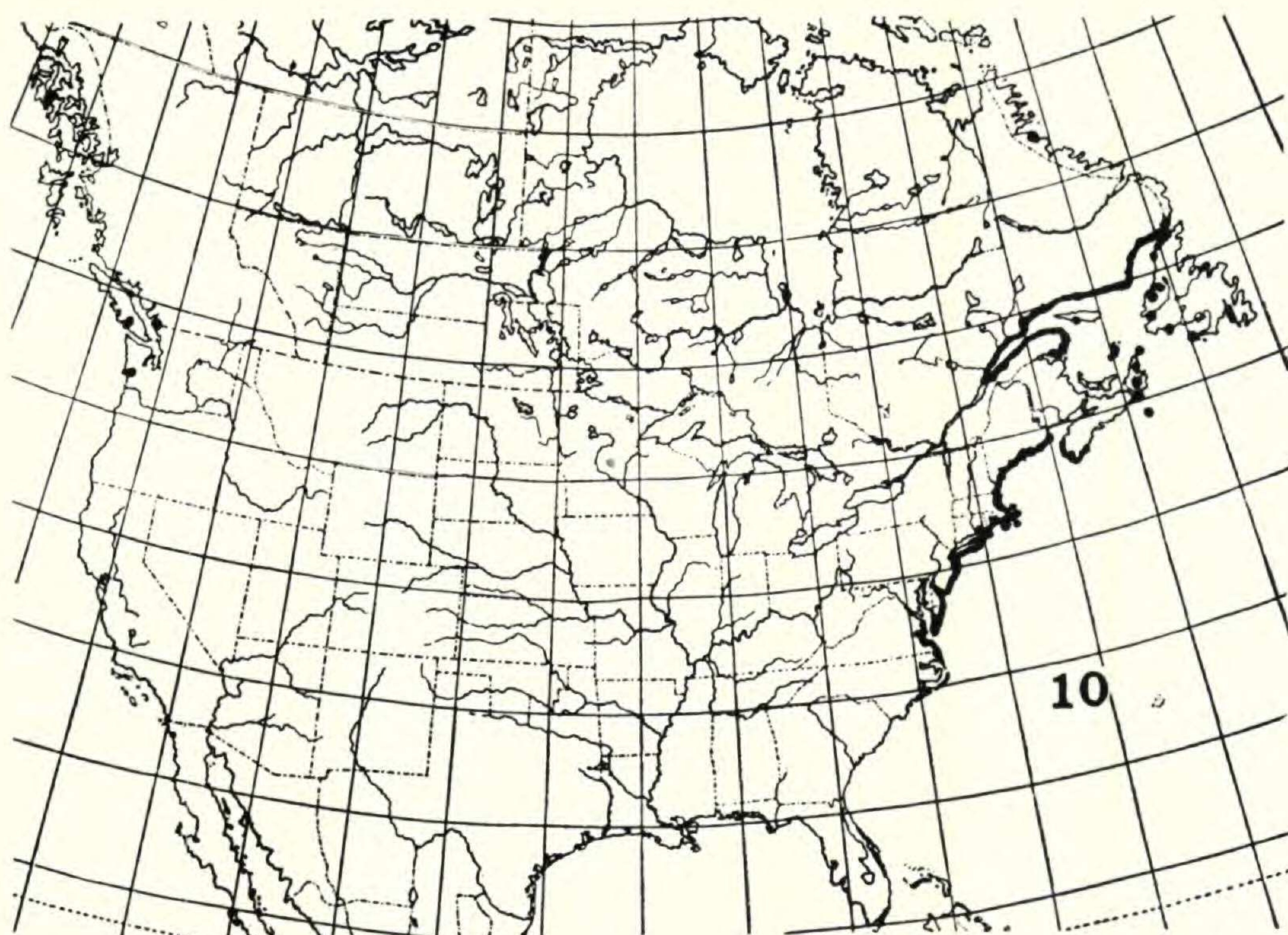
Upham, Warren, Geographic Limits of Species of Plants in the Basin of the Red River of the North. Proc. Boston Soc. Nat. Hist. xxv. (1890) pp. 140-172.



Map 7, Geographic Range of *Juncus Gerardi*;
8, of *Plantago juncooides*, var. *decipiens*.



Map 9, Geographic Range of *Carex glareosa*, var. *amphigena*.



Map 10, Geographic Range of *Zostera marina*;
11, of *Bidens hyperborea*.

In no case have these plants been reported as growing along the shores of Hudson Straits or along the northernmost Labrador coast. Four of them have been rarely found north of Hamilton Inlet; two reach their northern limits in Hamilton Inlet; and five are not known north of the Straits of Belle Isle.

Several expeditions¹ have recently gone to Labrador and, as each expedition has had among its members a trained botanist, whose work was to collect and study the flora at points touched, it is reasonable to assume that, since most of these plants have not been reported from far north on the coast, they do not usually occur north of the southern corner of Labrador (except as above stated); and their appearance along the shores of Hudson and James Bays has not been due to a migration along the outer coast of Labrador, thence by way of Hudson Straits to James Bay. Again, in no case have these plants been reported from the region between James Bay and the St. Lawrence River, the most inland point for any of them (*Bidens hyperborea*) along the St. Lawrence being northeast of Montreal. The absence of these plants from inland areas is to be expected, since they are strictly or primarily maritime, and it indicates that the edaphic conditions of the land lying between the St. Lawrence Basin and James Bay are at this time such as not to favor the presence of halophytic species. It is true, however, that much of the country lying north and northwest of the St. Lawrence River has not been carefully botanized and future exploration in this area may possibly reveal the existence of some of these species. If such should prove to be the case, the present problem would be more easily solved as will be later pointed out.

POSSIBLE CAUSES OF THIS DISCONTINUOUS DISTRIBUTION

The agencies which might have brought about this peculiar distribution are as follows:

- ¹ The reports from some of the recent expeditions referred to are as follows:
Fernald, M. L., A Botanical Expedition to Newfoundland and Southern Labrador. *RHODORA*, xiii. pp. 109-157 (1911).
Fernald, M. L. and Sornborger, J. D., Some Recent Additions to the Labrador Flora. *Ottawa Naturalist*, xiii. pp. 89-107 (1899).
Bishop, Harlow, List of Plants Collected on the Austin Labrador Expedition, 1928. Unpublished list at the Gray Herbarium.
Delabarre, E. B., Botanical Report of the Brown-Harvard Expedition to Nachvak, Labrador. *Bull. Geog. Soc. Phila.* iii. pp. 167-201 (1902).
Wetmore, R. H., Plants of the Hamilton Inlet and Lake Melville Region, Labrador, *RHODORA*, xxv. pp. 4-12 (1923).
Woodworth, R. H., List of Plants Collected on the Iselin Expedition to Northern Labrador, 1926. Unpublished list at the Gray Herbarium.

1. Driftless areas which may have harbored these plants during the Wisconsin glaciation.
2. Dispersal of these plants since the recession of the last ice sheet:
 - a. by means of wind.
 - b. by means of animals, other than birds.
 - c. by means of birds.
 - d. by means of water.
3. Migration of these plants along the shores of a marine connection between the St. Lawrence Basin and James Bay.

These agencies will now be considered in detail.

1. *Driftless Areas*. That driftless areas within the broad region invaded by Pleistocene ice occur is acknowledged by most geologists. The possibility of these areas harboring plants during the period of glaciation is unquestionable, for not only is an analagous condition now prevailing in the case of Greenland with its continental glacier, but, in addition, Fernald (30), in his remarkable studies upon the flora of Newfoundland and the Gaspé Peninsula, has definitely proved that in these regions such was the case. This fact is conceded by the great Canadian Pleistocene geologist, A. P. Coleman (19).

Many explorations have been made by geologists of the Canadian Government in the Northeastern part of Canada and the findings of such men as Bell, Low, Chalmers, Coleman, Tyrell and others largely agree concerning the glaciation of this area. Nowhere along the coasts or on the islands of either James Bay or southern Hudson Bay have areas been discovered which escaped the ruthless work of the Wisconsin ice sheet. The writer visited the region of James Bay during the summer of 1929 and found evidence of glaciation at every point touched: all along the rivers entering James Bay and along the southern and eastern coasts of the Bay itself. The same conditions were found on Charlton Island as also on a number of smaller islands which were explored. Mr. A. E. Porsild, one of the botanists for the Canadian Government, visited a number of the islands in James Bay, including Agamaski, the Twins and one large island off the coast at Fort George, and reported verbally to the writer that all these islands had been severely scoured by ice. In discussing Strutton and Trodely islands, Low (41) speaks of many large boulders strewn over the land.

Thus, the evidence is quite conclusive that driftless areas do not exist in the neighborhood of James Bay, and some other explanation

must be sought to account for the presence of the southern halophytic plants on the shores of this great inland sea.

2 a. *Wind.* Wind plays an important role in the dissemination of plants and plant parts. Seeds, or even plants, are often caught up by winds and carried varying distances before they are dropped or before they strike some obstacle which impedes their progress. Warming (64) claims that relatively heavy fruits may be carried by wind up to distances of at least sixteen miles. Many plants have their seeds modified for dispersal by this means and in the case of the dandelion, Small (51) claims " . . . that so long as the relative humidity of the air remains above 0.77 and so long as the fruit does not encounter an obstacle, a horizontal wind of 1.97 m.p.h. is sufficient for its dispersal to any distance." It is quite conceivable that a seed having once been dropped can again be picked up by wind and this process be repeated over and over again until long distances have been traversed. Again it is possible that a seed falling upon favorable soil might germinate and in succeeding years its seeds be blown to a new region and this process continue until long distances be crossed. There are, however, many elements of chance in such a hazardous mode of transportation, and the mortality in terms of successful germination and maturity, would of necessity be tremendous. In the case of plants establishing intermediate stations between two points it is difficult to apply this method of migration to halophytes over areas not favorable to salt-loving plants.

Fernald (30), in his studies upon the flora of Newfoundland, has furnished us a most striking example in point. To quote Professor Fernald, speaking of the absence from southwestern Newfoundland of many wind-dispersed species of Cape Breton: " . . . the distance across Cabot Strait, the shortest route from the southwestern mainland to Newfoundland is fully 70 miles, and, although this does not seem a forbidding gap, the fact remains that very many common Canadian species with fine spores or with the seeds plumose, feathery or otherwise adapted for wind-transportation, have failed to cross from Cape Breton to southwestern Newfoundland." Svenson (56), in his studies upon the interior distribution of halophytes, reached the conclusion that wind was not a predominant factor in seed-dispersal. Thus, the influence of wind as a primary factor in seed-dissemination (especially in the case of halophytes) over long distances has, perhaps, been overestimated and a more plausible cause for the occurrence of these plants in the Hudson Bay region must be sought.

2b. *Animals (exclusive of birds)*. Animals other than birds are responsible for local dissemination of plants and plant-parts. Those animals with which we need to concern ourselves are restricted to the mammals, for probably fish, amphibia, and reptiles play a very minor part in carrying seeds or plant-parts over such distances as are concerned in the present problem. Many plants have their seeds or fruits so modified as to allow them to cling to the fur of mammals and thus be carried along. In the species of plants under consideration no such modifications are present and the possibility of the seeds of such plants as *Glaux maritima* var. *obtusifolia* and *Zannichellia palustris* var. *major* being transported in this manner is very slight. Human travel has not been great between these two regions and we can scarcely look to this source as the means of introduction. Had these plants any food value or other economic significance, human migrations would of necessity have to be investigated.

2c. *Birds*. With birds, as with wind, there is no question but that they effect seed-dispersal locally. Concerning the distribution of plants or plant parts over long distances by birds, the question is highly debatable. Warming (63) sums up this matter in referring to Knud Anderson's work, supplemented by the conclusions of Winge, as follows: "For a number of consecutive years, thousands of birds, picked up dead at the Danish lighthouses have been sent to the Zoological Museum at Copenhagen, and notes on these dead birds have for many years been published annually by H. Winge. . . . This eminent zoologist writes to me," continues Warming, "as follows: 'In one of the first years, the contents of the stomachs were systematically examined, later on only occasionally, but the stomach has always proved to be empty. . . . Though I have had thousands of dead migratory birds between my hands and have made a habit of examining every single one, I have not as yet found any seeds adhering to the feathers, beaks, or feet.' "

Commenting upon the above observations, Warming continues: "As the above observations are made by so careful and eminent an investigator, I must consequently believe that birds at least very seldom carry seeds and other larger reproductive organs, and small plants, across great distances, and the indisputable evidences of birds carrying seeds either in them or adhering to them mentioned in books evidently apply to birds shot at or not far from, their daily haunts, and not to such as have just made a long journey." This

conclusion seems to be wholly sound and again forces us to seek a better explanation.

2d. *Water*. If the plants in question spread from the Gulf of St. Lawrence after the land to the north and northwest became freed from its burden of ice, only two now existing avenues of water were open for dispersal of seeds; namely, either the marine water along the coast of Labrador and thence through Hudson Straits, or the fresh water ponds and streams lying to the northwest of the St. Lawrence. As to the route via the North Atlantic and Hudson Straits, it seems wholly improbable that the dispersal took place by this route, for Guppy (34) has shown that only a few seeds have sufficient buoyancy to keep afloat in ocean-drift for more than a few days and that in the cooler regions of the globe, seed-drift is usually very scanty. Had seeds been carried short distances along the coast by this agency and in favorable spots established themselves, and had their progeny been transported in the same manner a short distance farther north, there establishing themselves and so on until the goal had been reached, it would be expected that more traces of the parent stock would be found along the outer coast of Labrador. As has been pointed out, no trace of some of these plants has ever been found north of the Straits of Belle Isle, while others are unknown north of Hamilton Inlet; and the few northern stations of the remaining species are exceeding localized.

Separating the St. Lawrence Basin and James Bay there is a divide which results in a double drainage system for this interior region. A large portion of this area drains to the south into the St. Lawrence River, while the remainder is drained to the north. After the recession of the Wisconsin ice-sheet, all the territory in north-eastern America stood at a much lower level than at present; yet it is possible that the divide existed in approximately the same relative proportions as at present, and if so, it is difficult to understand how water flowing south could be of assistance in the dispersal of seeds towards the north. If this intermediate water was fresh, migration for any great distance along its shores for strictly halophytic plants would be improbable. On the other hand, if the divide separating these two regions was much lower in proportion to the two adjacent areas, our problem would be simplified, for, as is soon to be pointed out, such a low basin would allow a marine connection between the two areas and thus permit migration of the plants in question along the shores of this inland sea.

Since the factors of driftless areas, dispersal by means of wind, animals, and water do not solve the present problem of seed dispersal, it is necessary to consider one more agency which, if proved to have existed, will help us out of the present dilemma. This last is the possibility of migration along the shores of a marine connection between the St. Lawrence Basin and James Bay.

THE CHAMPLAIN SUBMERGENCE

After the recession of the last ice sheet, as just noted, the north-eastern portion of the North American Continent lay at a much lower level than is the case at present. In support of this statement Taylor (61) says that: “. . . nothing within the realm of Pleistocene geology is more clearly established than the depression of land during the growth of the Wisconsin ice sheet in the region of the Great Lakes. . . .” This lowering of the Continental land mass resulted in the drowning of the St. Lawrence and Ottawa valleys. Chalmers, Dyer, Kindle, Bell, Low, Keele, Coleman, Taylor, Dowling, Tyrell and others all agree that such a submergence took place. Additional evidence of a marine invasion is supplied by the presence in these formerly submerged areas of large deposits of marine clays, many of which bear numerous fossils, such as: *Mya arenaria* Linn., *Mya truncata* Linn., *Saxicava arctica* Linn., *Macoma calcaria* Gmel., *Macoma balthica* Linn., var. *groenlandica* Beck., *Mytilus edulis* Linn., *Serripes groenlandicus* Gmel., *Leda pernula* Müll.

Many localities have been reported for these marine shells and the following TABLE 1 gives a selected list, including only those which show the highest elevation. The localities listed in TABLE 1 have been plotted on the accompanying map and are indicated by solid black circles, together with the elevation in feet above sea level. These points have been connected and the enclosed area filled in by vertical lines. Thus, a clearer conception may be gained of the extent of this so-called Champlain Submergence as based upon the actual finding of marine fossils.

An interesting point to note in this connection is that these fossils are not evenly distributed throughout the known region of submergence. Many areas occur at much lower altitudes than those given in the above list, which are barren as concerns fossil shells. Chalmers (14) has pointed out that no marine shells have been found

TABLE 1
MARINE DEPOSITS

Location	Approx. Latitude	Approx. Longitude	Height in feet above sea level		Authority
North Gower.....	45° 10'	75° 45'		marine shells	Reinecke (48)
Prescott.....	44° 40'	75° 30'	320-350	marine shells	Coleman(20)
Welch's Siding.....	45° 0'	76° 0'	440	whale remains	Taylor (57)
Oswego.....	43° 30'	76° 30'	246	very probable	Taylor (57)
Covey Hill.....	45° 0'	73° 45'	460	very probable	Fairchild (28)
Chelsea.....	45° 30'	75° 40'	450	marine shells	Ells (23, 24)
Cantley.....	45° 30'	75° 40'	450	marine shells	Ells (24)
McGregor Lake.....	45° 30'	75° 40'	450	marine shells	Ells (24)
Arnprior.....	45° 30'	76° 50'	470	marine shells	Low (40)
Glengary County, Ont.....			350	marine shells	Ells (24)
Calumet Island, Que.....			200-500	marine shells	Chalmers (17)
Lake St. John.....			200-300	marine shells	Chalmers (17)
Grenville Dist.....	45° 30'	74° 30'	735	marine shells	Richardson (49)
Buckingham Map Area.....	45° 30'	75° 30'	600	marine shells	Ells (23)
Neapean township (6 miles up Rideau River from Ottawa.....	45° 30'	75° 45'	350	marine shells	Wilson (68)
Brockville.....	44° 45'	75° 30'		marine shells	Coleman (20)
4 miles above Ha Ha Bay on River Ona- bonchbagame.....				marine shells	Chalmers (17)
Portneuf.....	48° 20'	71° 0'	300	marine shells	Richardson (49)
Rivière du Loup.....	46° 45'	71° 50'	150	marine shells	Richardson (50)
St. Amboise.....	47° 15'	70° 15'	345	marine shells	Chalmers (15)
Beauport.....	47° 0'	71° 0'	515	marine shells	Low (42)
Little Magog.....	47° 0'	71° 30'	265	marine shells	Low (42)
	45° 15'	72° 0'	690	marine shells	Chalmers (14)

in the beds representing Leda clays and Saxicava sands of New Brunswick. He goes on to say that only a few localities on the west coast of Prince Edward Island have Pleistocene marine fossils: " . . . though a large area now forming dry land must have been under the sea, which was doubtless then, as at present, inhabited by marine animals."

Again Ells (24), in speaking of the lower Ottawa and St. Lawrence valleys, says: " . . . throughout the district there are great expanses of marine clays which show no trace of organisms, while very often the overlying sands and gravels hold great quantities of marine fossils." Thus it may be safely concluded that the absence of marine fossils does not necessarily mean the absence of marine waters.

The extent of this post-pleistocene marine submergence has never been definitely shown and at present there is much disagreement among geologists concerning the matter. The presence of marine fossils is reliable evidence as to depth of submergence, but, in addition to this, many raised beaches have been discovered and described. Whether these are of marine or lacustrine origin is still a moot question.

TABLE 2 gives a list of some of these raised beaches together with their approximate location and their altitudes.

TABLE 2

RAISED BEACHES—PROBABLY MARINE

Location	Approx. Latitude	Approx. Longitude	Height in feet above sea level	Authority
Texas.....	43° 40'	75° 15'	262	Fairchild (28)
Henderson.....	43° 50'	76° 10'	320	Fairchild (28)
Clayton.....	44° 15'	76° 0'	400	Fairchild (28)
Yarker.....	44° 25'	76° 50'	450	Mather (44)
Inverary.....	44° 25'	76° 0'	510	Mather (44)
St. Remi.....	46° 0'	74° 45'	701	Wilson (66)
Rockaway.....	46° 0'	74° 45'	663	Wilson (66)
Ottawa.....	45° 30'	75° 40'	690	Mather (44)
Belleville.....	44° 10'	77° 25'	323	Taylor (57)
Brighton.....	44° 0'	77° 45'	309	Taylor (57)
Trenton.....	44° 10'	77° 30'	320	Taylor (57)
Baie St. Paul.....	47° 30'	70° 30'	500	Mandsley (43)
Sweetsburg.....	45° 10'	73° 40'	610-700	Chalmers (13)
Frelighsburg.....	45° 0'	72° 50'	475-785	Chalmers (13)
Shefford Mt.....	45° 25'	72° 30'	820	Chalmers (13)
St. Charles.....	46° 50'	71° 0'	540-550	Chalmers (12)
St. Anselm.....	46° 40'	71° 0'	620	Chalmers (12)
St. Henedine.....	46° 30'	71° 0'	750	Chalmers (12, 16)
St. Marie.....	46° 25'	71° 0'	760	Chalmers (12)
St. Joseph Lake.....	46° 10'	71° 30'	860	Chalmers (12)
St. Jule Sta.....	46° 20'	71° 40'	895	Chalmers (12)
Dudswell.....	45° 30'	71° 30'	850	Chalmers (12)
Lake Memphremagog...	45° 20'	72° 0'	865-990	Chalmers (12, 14)
La Chute.....	45° 40'	74° 20'	1000	Ells (24)
Lewiston, N. Y.....	43° 10'	79° 0'	385	Spencer (53)
Watertown, N. Y.....	44° 0'	75° 50'	730	Spencer (53)
Fine, N. Y.....	44° 15'	75° 10'	972	Spencer (53)
Malone, N. Y.....	44° 50'	74° 15'	1100-1200	Chalmers (11)
St. Anne de Beaupré....	47° 0'	71° 0'	540	Chalmers (11)
North of Quebec.....	46° 50'	71° 10'	560	Chalmers (11)
Lake Maskinong.....	46° 20'	73° 30'	560	Chalmers (11)
St. Jerome.....	45° 45'	74° 0'	900	Chalmers (11)
Kingsmere Mt. (North of Ottawa).....	45° 30'	75° 45'	965	Chalmers (11)
North side of Ottawa River just above Allu- mette Is.....	46° 50'	76° 50'	800	Chalmers (11)
Brulé Rapid.....	46° 30'	76° 0'	700	Keele (38)
Georgeville.....	45° 10'	72° 0'	920	Spencer (53)
Magoon Point.....	45° 0'	72° 0'	950	Spencer (53)
Danville.....	45° 50'	72° 0'	890	Chalmers (16)

It will be noted from the list in TABLE 2 that these raised beaches range from a few feet above sea level to 1200 feet. Their localities are indicated on the accompanying map by hollow circles, with their altitudes. These points have been connected and the area included filled in by horizontal lines.

Marine fossils have not been found in the Champlain, St. Lawrence, and Ottawa regions above an altitude of approximately 735 feet.

This fact has led some geologists to search for some theory other than marine invasion to account for the non-fossiliferous raised beaches. The theory of Glacial Dams has received considerable support. In discussing the Iroquois beach as having been formed by an arm of the sea, Coleman (20) states, "This conclusion is a very natural one and tends toward simplicity by avoiding the assumption of an ice dam; but the finding of fresh water shells in the Iroquois beach near Toronto seems conclusive as to the character of the water, which could hardly remain fresh or even brackish with an opening seventy or eighty miles wide and four hundred feet deep into the inland sea formed by the enlarged Gulf of St. Lawrence." Spencer (54) is opposed to this view and he states: "As we ascend to the elevation of the higher beaches, the question of glacial dams becomes more and more difficult, for we must assume them to have been hundreds of miles long and at enormous altitudes, damming up waters which had the proportions of inland seas." He then goes on to say, "I am compelled to assume the initial plane of the Algonquin beach to be at sea level." Later in the same paper Spencer says, ". . . there is additional evidence; for crustaceans of marine species have so adapted themselves as to still live in the depths of Lake Superior (55, 52), as also maritime plants along its shores." (36)

Conceding the existence of the glacial dams, which would account for the higher beaches to the north of the Great Lakes, they would not account for the occurrence of the raised beaches found along the valley of the St. Lawrence River. As Chalmers (13) has stated, "All the shore-lines noted face the open plain of the St. Lawrence valley No barriers exist or could have existed, capable of holding in a body of fresh water at heights sufficient to allow the formation of these shore-lines; and the only reasonable theory as to their origin seems to be that they were formed along the margin of a sea which occupied the St. Lawrence valley in the Pleistocene period." Dr. Ells (24) agrees with Chalmers, for he says "The underlying clays at the higher levels up to nearly one thousand feet, and in places to a height of considerably more than this, are apparently continuous with those of undoubted marine origin to the north and east, and the inference naturally follows that all the deposits were laid down by the same agencies. The absence of marine organisms over a large part of the area is only negative evidence to the contrary, and there are certain facts that go far to establish

this theory of their marine deposition." In the same article, Dr. Ells continues: "There is no break apparent in the deposition of these beds, from the nodule-bearing clays near Ottawa to the most northerly outcrops on the Gatineau and the Lièvre where the clays are, in so far as yet known, all barren."

The question might well be asked as to the relative ages of the different beaches under discussion, and so far as known they seem to be all of post-glacial origin. Taylor (58) has summed up this matter as follows: "I express again, and with increased confidence, the belief that the Iroquois beach and the highest beaches in the lower St. Lawrence, Champlain, Huron, and Ottawa valleys, and in the basins of Lakes Huron, Michigan, and Superior, and also in the valley of the Red river of the North, are all one continuous shore line of the sea."

If these conclusions of Spencer, Ells and Taylor be correct, it would follow that this marine invasion just after the recession of the last ice-sheet was much greater in extent than is indicated by the altitudes at which marine fossils have been found. The same factors which are responsible for the lack of marine fossils in areas unquestionably once covered by the sea, as was pointed out earlier in this paper, may account for the lack of fossils in these raised beaches. Chalmers (14) has suggested "That the arenaceous clays and the sand which together constitute the stratified deposits lying below the uppermost shore line of the Pleistocene submergence, contain minerals destructive to shells and tests of marine animals."

Finally, in James Bay today no living marine mollusks are to be found, except perhaps in the northern part, owing probably to the muddy and brackish nature of the water (9). A similar condition might well have existed during the Champlain Submergence in which the waters were muddy and brackish, not permitting the existence of marine life, yet allowing the existence of plants of maritime habitats along its shores.

If, then, these raised beaches owe their origin to marine water (and there seems to be considerable evidence in support of this hypothesis) the invasion by the sea would have reached the Lake Temiskaming region, involving also Lakes Ontario and Nipissing. Reference to the accompanying large map will show the area involved, which is indicated by horizontal lines.

(To be continued)